ISSN : 2249 - 8877 Volume 7 Issue 1

Research & Reviews On Polymer

Full Paper

RRPL, 7(1), 2016 [001-006]

Assessement of local sponge (*luffa aegyptiaca*) filled natural rubber vulcanizate

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ABSTRACT

The assessment of luffa aegytiaca as filler in natural rubber vulcanizates was carried out. Samples of luffa aegytiaca filler (LAF) were milled to fine powder sieved through a 50μm mesh and were used in compounding natural rubber. The characterization results present excellent values of pH, moisture content, ash content, loss on ignition, iodine value and bulk density. The mechanical properties of the luffa aegytiaca filler (LAF) filled vulcanizates present optimum tensile strength at 25phr before decreasing, modulus at 100%, abrasion resistance and hardness increases with filler loading while compression set, elongation at break and flex fatigue resistance decreases with filler loading.

KEYWORDS

Loading;
Filler;
Vulcanizates;
Luffa-Aegytiaca;
Characterization;
Mesh.

INTRODUCTION

Historically mankind has been familiar with several applications of composite material for housing and building construction. The mechanism of reinforcement of elastomers by filler is considered that the effect of filler is to increase the number of chains, which share the load of a broken polymer chain. It is known that in the case of filled vulcanizate, the efficiency of reinforcement depends on a complete interaction of several filler related parameter[1, 3]. They include particle size, particle shape, particle dispersion, surface area and surface reactivity interaction, structure of the filler and rubber matrix[1]. In the raw state, rubber has virtually no engineering applications. It become necessary to incorporate additives into the polymer in order to ensure easy processing characteristics, desired cure properties in the finished products, product cost and reduction and enhances service performance[2]. Recent research proved that more than 65% of chemist, scientist, engineers and nearly all physicist are involved with research or development work with polymers[4]. The addition of filler to rubber has helped to achieve another important function apart from increasing hardness and modulus of rubber. They also improve processability, resistance to abrasion, tensile and tear strength as well as reduce cost of rubber products[5, 6]. Locally sourced agricultural by-products have been discovered as potential fillers over the years as a result of investigation. Luffa aegytiaca has been waste products in the past years and the need to investigate its potentiality as filler become a major concern in the present day rubber industry. This re-

TABLE 1 : Materials and their sources

Materials	Sources
Natural Rubber (NSR-10)	Rubber Research Institute, Iyanomoh, Benin City
Local Sponge (Luffa-Aegyptiaca)	Uromi, Edo State
Tetramethyl thiuram disulphide (TMTD)	British Drug House (BDH), England
Mercarpto benzothiazole sulphenamide (MBTS)	British Drug House (BDH), England
Stearic acid	British Drug House (BDH), England
Sulphur	British Drug House (BDH), England
Trimethylquinoline (TMQ)	British Drug House (BDH), England
Zinc Oxide	British Drug House (BDH), England
Processing Oil (Paraffin Wax)	British Drug House (BDH), England
N330 Carbon black	British Drug House (BDH), England

TABLE 2 : Formulation for compounding natural rubber

Ingredients	A (phr)	B (phr)	C (phr)	D (phr)	E (phr)	F (phr)	G (phr)
Natural Rubber	100	100	100	100	100	100	100
Filler (LAF)	-	10	15	20	25	30	35
Zinc oxide	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Stearic acid	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Sulphur	1.5	1.5	1.5	1.5	1.5	1.5	1.5
TMTD	3.5	3.5	3.5	3.5	3.5	3.5	3.5
MBTS	1.5	1.5	1.5	1.5	1.5	1.5	1.5
TMQ	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Processing Oil	5.0	5.0	5.0	5.0	5.0	5.0	5.0

A batch factor of four (4) was used.

TABLE 3 : Mixing steps and time

Mixing Steps	Time (minutes)
Natural rubber mastication	6
Addition of Stearic acid	1
Addition of Zinc Oxide	2
Addition of filler (LAF)	11
Addition of MBTS	1
Addition of TMTD	1
Processing Oil	2
Addition of Sulphur	2
Total	25

search is to find out whether luffa aegytiaca can serve as fillers or not and if so whether reinforcing, semi reinforcing or non-reinforcing since its potentiality as fillers will help to cheapen the price of rubber products, improve their quality and could as well lead to ban on importation of fillers and could even lead to exportation thereby improving balance of trade[7].

TABLE 4 : Characteristics of the powdered fillers

Parameter	Value
Loss on ignition	22.50
Moisture content (%)	1.30
pH of slurry	6.60
Iodine adsorption number (g/mg)	31.01
Particle size distribution (μm)	50
Bulk Density (glml)	0.86
Ash Content (%)	1.08

Objective

To assess local sponge (*luffa aegyptiaca*) as filler in natural rubber vulcanizates and evaluating the mechanical properties

EXPERIMENTAL

Materials

The equipments used include

a. Monsanto Tensile Tester Model 1/m, Manufactured by British Company Limited, England

b. Wallace Hardness Tester Model c8007/25, Elektron Technology Series, UK.
c. Wallace Akron Abrasion Tester, Elektron Technology Series, UK.
d. DuPont Machine, Manufactured by British Company Limited, England
e. Muffle Furnace METTm-525, Elektron Technology Series, UK.
f. Two Roll Mill, Manufactured by British Company Limited, England
g. Hydraulic press, Elektron Technology Series, UK.

Method

Filler preparation and characterization

Luffa-aegyptiaca gotten from local bushes was dried properly in air to remove the shells and seeds from it. Thereafter, milled into fine powder and sieved through a mesh size of 50µm. The powdered luffa-aegyptiaca was then characterized in terms moisture content, bulk density, pH, ash content, loss on ignition and iodine value and use for the compounding natural rubber.

Processing of the composites

This involves the compounding of natural rubber with local sponge (*luffa aegyptiaca*) powdered fillers.

The formulation used for the compounding of the natural rubber (NSR 10) with the local sponge (*luffa aegyptiaca*) powdered fillers is given in TABLE 2

Mixing procedure

The rubber mixes were prepared on a laboratory size two roll mill according to the mixing cycle shown in TABLE 3. It was maintained at 70°c to avoid cross-linking during mixing after which the rubber composite was stretched out. Mixing follows ASTMD 3184–80 Standard.

Compounded composite curing

The curing of test pieces was carried out at 120°C for 20 minutes under a pressure of 2.8bar.

RESULTS

Discussion

TABLE 5, clearly indicates a noticeable value

TABLE 5 : Mechanical properties of luffa-aegyptiaca filled vulcanizates

Property	Filler Loading (phr)						
	0	10	15	20	25	30	35
Tensile Strength(MPa)	9.48	10.23	11.18	14.01	16.22	13.15	12.20
Modulus (MPa)	1.13	1.60	1.72	1.79	1.83	1.98	2.08
Elongation at Break (%)	886	782	688	602	583	501	456
Hardness (IRHD)	44.00	46.02	49.22	51.12	52.64	54.43	65.21
Compression Set (%)	28.61	29.01	16.58	15.60	12.22	10.98	8.01
Abrasion Resistance (mm^3/500rev)	40.10	40.92	41.60	42.32	43.20	45.10	48.08
Flex fatigue($kcx10^3$)	21.00	8.93	8.03	7.88	7.62	6.91	6.02

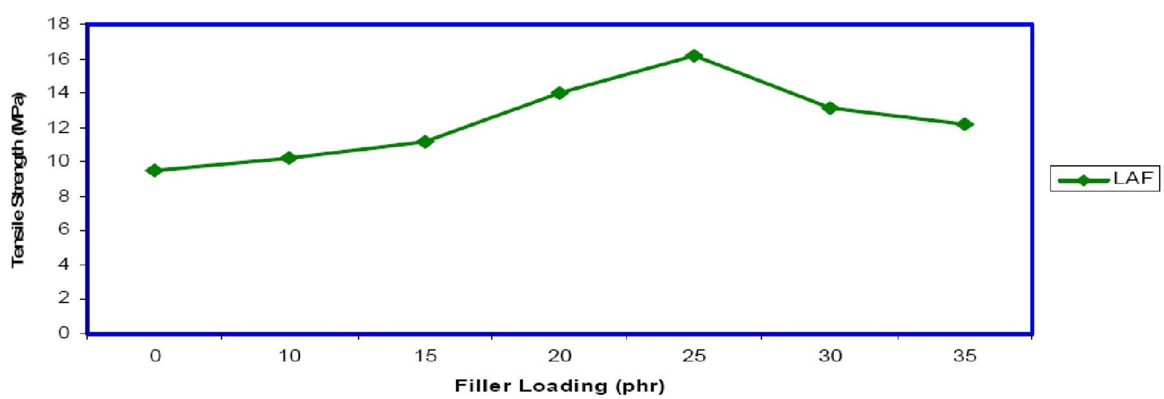

Figure 1 : Tensile strength of LAF-filled vulcanizates

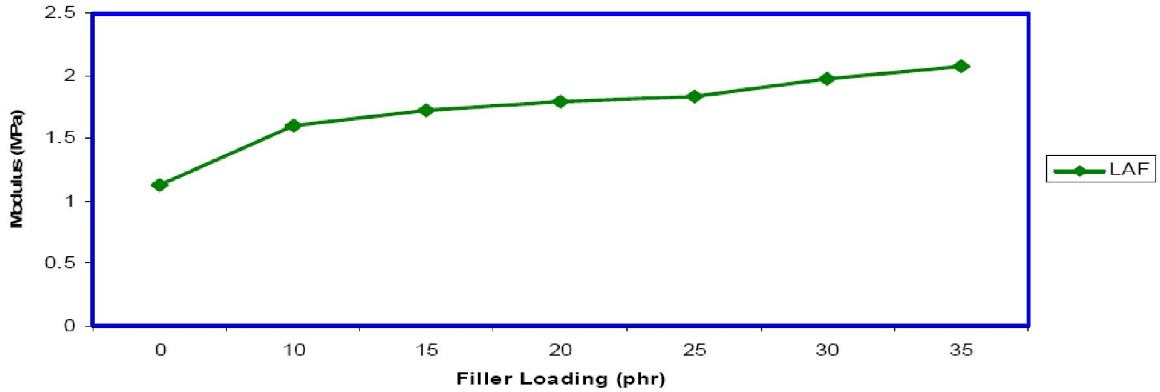

Figure 2 : Modulus of LAF-filled vulcanizates

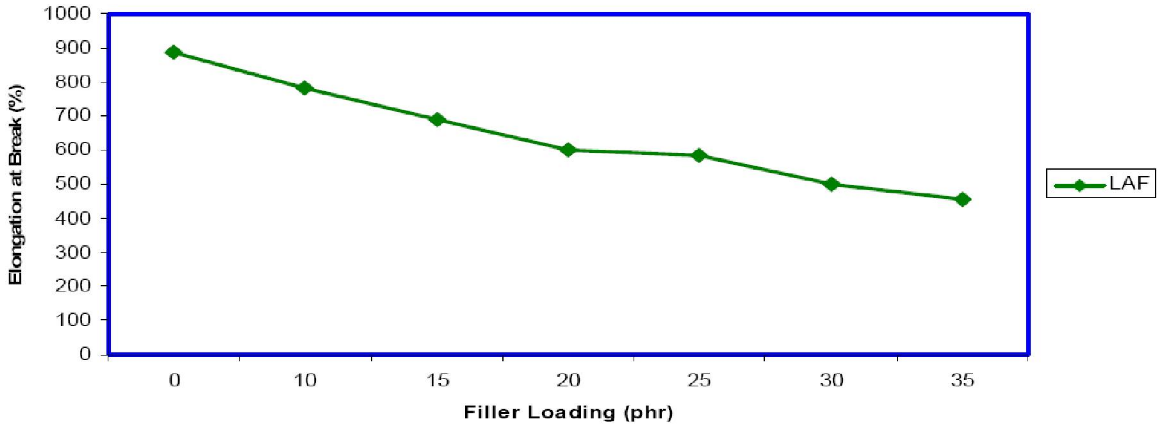

Figure 3 : Elongation at break of LAF-filled vulcanizates

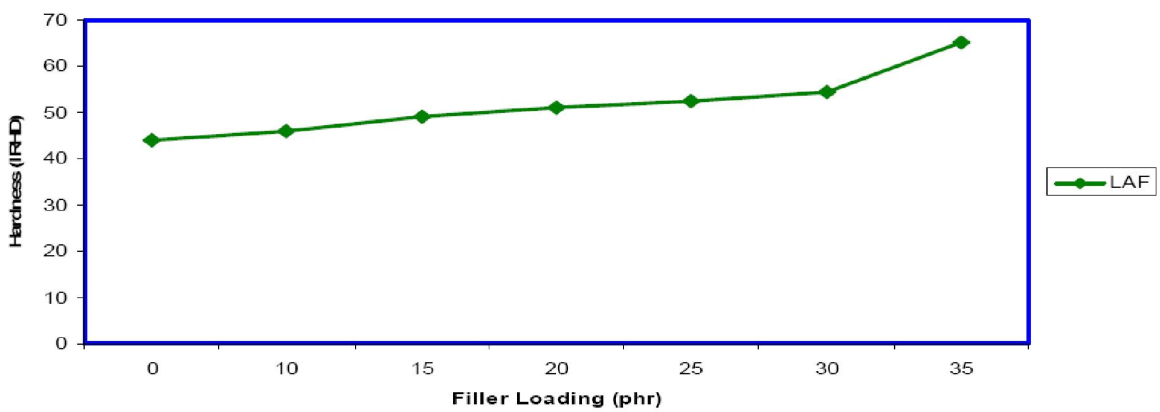

Figure 4 : Hardness of LAF-filled vulcanizates

in tensile strength and modulus of luffa-aegytiaca filler (LAF) filled vulcanizates. It may be mentioned here that both tensile strength and modulus are important for recommending any vulcanizate for structural applications. The increase in tensile strength and modulus is as a result of high surface area of luffa-aegytiaca filler (LAF), suggest better polymer filler interaction and hence enhanced better tensile properties for the luffa aegytiaca filler (LAF) filled Vulcanizate. The factors that affect the reinforcing potentials of fillers include filler dispersions, surface area, surface reactivity, bonding capacity (quality), particle size between the filled and the elastomeric matrix[8, 9].

The elongation at break (EAB) for the luffa-aegytiaca filler (LAF) filled vulcanizates approaches that of N330 carbon black showing superior service performance which has been explained in terms of adherence of the filler to the polymer phase leading to the stiffening of the polymer chain and hence re-

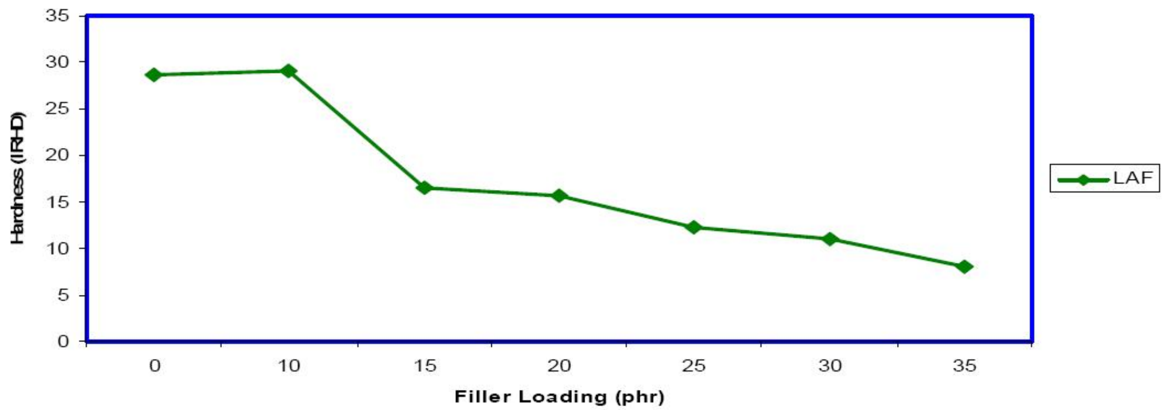

Figure 5: Flex fatigue resistance of LAF-filled vulcanizates

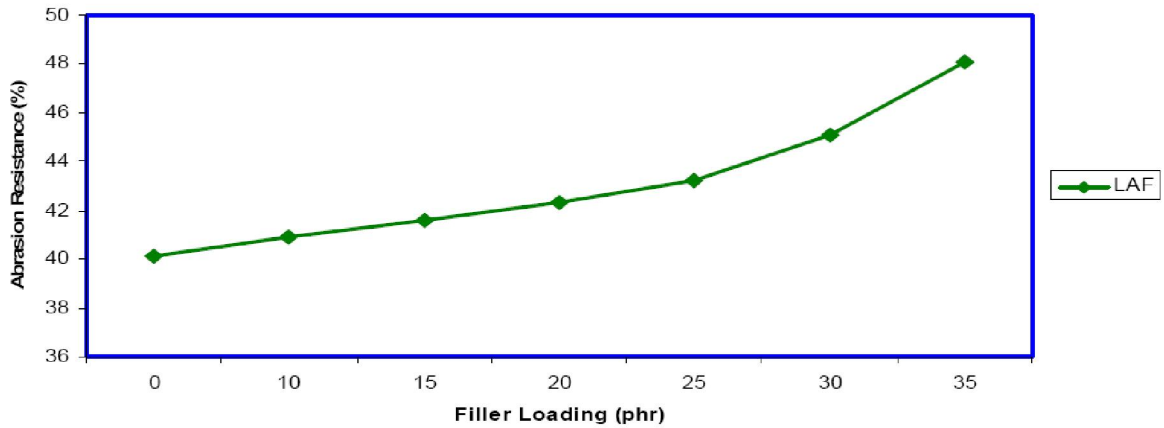

Figure 6 : Compression set of LAF-filled vulcanizates

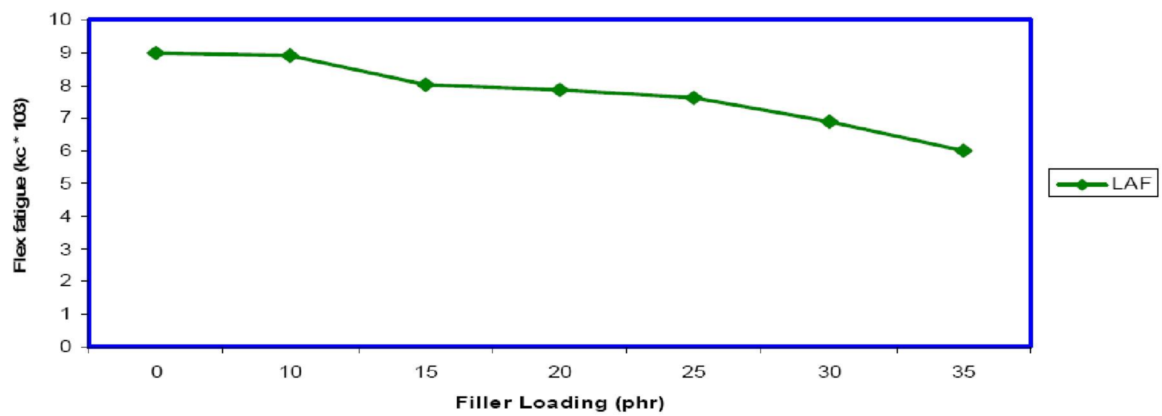

Figure 7 : Abrasion resistance of LAF-filled vulcanizates

sistance to stretch when the strain is applied.

The hardness results of luffa-aegytiaca filler (LAF) filled vulcanizates are higher as shown in TABLE 5 because of the more adherence of luffa-aegytiaca filler (LAF) to the rubber matrix.

The results of compression set in TABLE 5 showed that luffa-aegytiaca filler (LAF) filled vulcanizates exhibits excellent compression set which is connected with the degree of filler dispersion and its particle size which may have enhanced it performance in service life.

The values of flex fatigue of the luffa-aegytiaca filler (LAF) filled vulcanizates shows higher values which decreases with filler loading. The decrease in flex fatigue has been explained in terms of adherence of the filler to the polymer phase leading to the stiffening of the polymer chain and hence resistance to stretch when strain is applied.

The abrasion resistance of a solid body is defined as its ability to withstand the progressive removal of the material from its surface as a result of the mechanical action of rubbing, scraping or erosive nature[8]. The trend of abrasion resistance presented in TABLE 5 showed that luffa-aegytiaca filler (LAF) filled vulcanizates has better resistance to surface scratching.

CONCLUSION

This research examined how the luffa-aegytiaca filler (LAF) particle size may influence its characteristics properties and hence the mechanical properties of natural rubber vulcanizates and the possibility of a comparative study on the mechano-absorption properties of the vulcanizates. The initial result shows that luffa-aegytiaca filler (LAF) has high reinforcement for natural rubber compound. The reinforcing potential of luffa-aegytiaca filler (LAF) is best compared to that of N330 carbon black in some measured properties. The result also predicts the potential applications of luffa-aegytiaca filler (LAF) as low cost filler in natural rubber products exhibiting high quality characteristics.

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